DEVELOPMENT, IMPLEMENTATION, AND EVALUATION OF A CASE STUDY ON GENE THERAPY

An Undergraduate Honors Thesis

by

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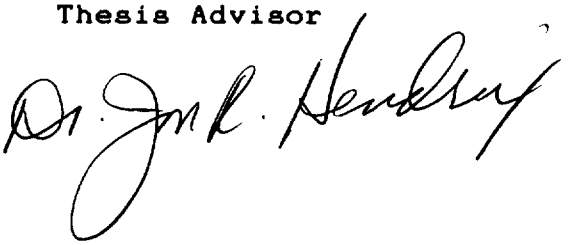

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Abstract

This research project consisted of developing three case studies--one on gene therapy and two on the Human Genome Project (HGP). The gene therapy case study was implemented and evaluated in Honors 299, a Ball State University Honors College course, and also in an Advanced Biology class at Western High School in Russiaville, IN. Students used the case study in conjunction with either a decision-making model or student discussion group. The case study was evaluated by administering pretests and post-tests to the students and comparing the data obtained. From the results, it was determined that the case study was effective as a teaching strategy for bioethical decision-making. Both this case study and the case studies on the Human Genome Project will be used in future biology courses at Ball State University.

DEVELOPMENT, IMPLEMENTATION, AND EVALUATION OF A CASE STUDY ON GENE THERAPY

Biology 299 is a Ball State University Honors College course which focuses on human genetics and bioethical decision-making. To promote education in these areas, case studies, which present ethical dilemmas for students to identify and personally resolve, are commonly utilized. In conjunction with the case study, a bioethical decision-making model or discussion group is used to provide students with a format for which to engage in ethical analyses. The combination of the case study and the decision-making model or discussion group serves to meet the following primary objective: "to enhance [students'] content acquisition, decision-making skills, and content application to real-life problems" (Pursifull 1986). This goal is attained by first providing students with the opportunity to familiarize themselves with ethical problems resulting from the application of scientific knowledge and technology. After the ethical problems are presented and identified as such, students engage in ethical analyses by considering the problems from several different reference points and by examining and affirming their own values, morals, and ethical principles. This process facilitates the

formulation of individual decisions and increases the likelihood that these decisions will be adhered to in real-life situations (Hendrix 1978; Mertens and Hendrix 1983).

In Bioethics: Bridge to the Future (1971), author Van Rensselaer Potter states that:

> Mankind is urgently in need of new wisdom that will provide the 'knowledge of how to use knowledge' for man's survival and for the improvement in the quality of life.....

This urgency is especially evident in today's society. New knowledge abounds in the scientific community, as astonishing discoveries are being made and exciting technologies are being developed. The Human Genome Project (HGP) and one of its products, gene therapy, raise a wide diversity of ethical issues which will undoubtedly have a profound impact on each member of the global society. Thus, it is critical that today's citizens possess the skills needed to deal effectively with such issues. In addition, ethical issues exist outside the scientific sphere. The increasing prevalence of AIDS, the widespread use of drugs, and the existence of violence and racism are just some of the problems which face today's citizens. Often, these types of problems are especially prominent in the younger generation. U.S. Senator Dan Coats (R-Indiana) has stated:

> I've seen the parade of pathologies...they are unending and increasing. Suicide is now the second leading cause of death among adolescents, increasing 300 percent since 1950. Teen pregnancy has risen 621 percent since 1940. More than a

> million teenage girls get pregnant each year. Eighty-five percent of teenage boys who impregnate teenage girls eventually abandon them. The teen homicide rate has increased 232 percent since 1950. Homicide is now the leading cause of death among 15 to 19 year-old minority youths. Every year substance abuse claims younger victims with harder drugs. A third of high school seniors get drunk once a week. The average age for first-time drug use is now 13 years old (Imprimis 1991).

Clearly, it is evident that today's students need instruction in ethical analysis, critical thinking, and decision making so that they will be able to deal effectively with these issues when they encounter them in their own lives.

Because opposition to the teaching of values in the schools is often expressed, it is important to note that bioethical instruction does not result in a transmission or an imposition of a particular set of values. On the contrary, bioethical decision-making provides students with the opportunity to consider many possible values and choices associated with a given issue and to understand the probable consequences of implementing any of several solutions. By doing so, students are actually encouraged to develop their own value systems. Both the decision-making model and discussion group formats were developed by Dr. Jon Hendrix, and were based on the value/moral developmental theories of Dr. Brian Hall, Dr. Lawrence Kohlberg, and Dr. Jean Piaget (Pursifull 1986).

Statement of the Problem

This research project was divided into three major components. The first component involved the development of a case study to be used either in conjunction with a decision-making model or with a discussion group format. Three case studies were developed, with one focusing on the ethical issues created by gene therapy and two dealing with the ethical implications of the HGP. According to Dr. Jon Hendrix (1980):

> The first step in value-clarifying, decision-making is the examination of data and identification of a problem as being an ethical problem. Recognition of an ethical/value clash problem depends upon two criteria: an ethical problem exists (1) when there is a real choice between possible courses of action, and (2) when the person making the choice must place significantly different values upon each possible action or the consequences of each action.

The second component of the research consisted of implementing one of the case studies as a bioethical strategy. This was done in two test populations, with the case study combined with either a discussion group or a decision-making model. The third component of the research involved evaluating the effectiveness of the bioethical strategies as educational tools. To assess their efficacy, pretests were administered to students in the test populations before they were presented with the case study. After receiving the case study, students either completed a bioethical decision-making model or participated in a

student discussion group. This was followed by administration of a post-test with content identical to that of the pretest. Results were compared and quantified to obtain a measure of effectiveness for the case study as used as a strategy for bioethical instruction.

Literature Review

The importance of bioethics as an educational component becomes evident upon examination of students' needs in today's society. Bioethical instruction can improve students' problem solving, learning, and decision-making abilities. An understanding of bioethics also increases students' motivation to study science, promotes their moral development, and enables them to deal effectively with value-laden science. Therefore, a biology curriculum that contains a bioethical component is clearly of benefit to students.

Bioethics can, in itself, serve to make the field of biology a more attractive discipline to study. Traditional biology curriculums have consisted largely of rote memorization of facts, with little opportunity for creative or analytical thinking (While 1983). As a result, many students are discouraged from pursuing education in this field. Although many people do not find science to be personally meaningful, many do enjoy the social aspects of scientific issues. Statistics have suggested that students who are familiar with socially-related scientific information express a higher level of interest than do those exposed only to traditional science curriculums (Urbano 1984). Indeed, Mertens and Hendrix have found that

"students are more likely to be motivated to study science if they see it has personal meaning for them. Many students have a negative view of science and science courses due to the fact that they perceive it as 'a collection of facts to be memorized and regurgitated on tests.' Science becomes real and important to students when they have an opportunity to think and work rationally with the issues raised by science" (Urbano 1984).

The incorporation of a bioethical component into a science curriculum increases the probability that "real learning" will occur. Not only does the "rote memorization" commonly associated with biology render the field unattractive for many, it also hinders the degree to which actual learning--in which the material is thoroughly understood--occurs. Many students engage in the habit of memorizing material for examinations, only to forget it immediately or soon after the testing periods are completed. This is especially true for material which is not personally meaningful. Thus, learning that results in students grasping and retaining the material presented does not often take place (Pursifull 1986). In his study on critical thinking, Edward Glasper found that schools tend to employ teaching methods which focus on "feeding" detailed facts to students in the form of "ready-made generalizations and conclusions" which students are later expected to replicate on examinations. Because the students are not required to derive their own answers or examine the concepts behind

them, they tend to internalize very little of the information presented to them (Urbano 1984). Indeed, the majority of educators maintain that students are not likely to assimilate material unless it is personally relevant to them (Pursifull 1986). This aspect of relevance is added to science curriculums when value issues are introduced because they require the student to examine his or her own beliefs and ethical stances. Therefore, the bioethical component, which centers around value issues, is a crucial part of a curriculum.

Bioethics also provides students with an opportunity to further their moral development. "According to Kohlberg, the most important stimulus to moral development is cognitive conflict, the doubts which arise when one's formerly accepted judgments lead to contradictions, or uncertainty when faced with difficult and unfamiliar decisions. Many of today's advances in the scientific discipline involve ethical conflicts and require moral reasoning. . . bioethical issues can be raised to impart new meaning and significance to biology content" (Urbano 1984). Kieffer further maintains that, for students to emerge from public schools as productive citizens, morality and ethics must be dealt with within the educational framework. He asserts that, because many controversies involving moral issues emerge from new biotechnologies, the subject of biology allows educators a great opportunity to facilitate the moral development of students (Pursifull 1986).

In addition, bioethical analyses permit students to engage in value clarification. Toffler emphasized the importance of values, stating, "No problem in education has been more disgracefully neglected...than values. Having supported the myth of a value-free education, we now find millions of young people moving through the educational sausage-grinder who have never been encouraged to question their own personal values or to make them explicit. In the face of a rapidly shifting, choice-filled environment, one which demands decision after adaptive decision, this neglect of value questions is crippling" (Urbano 1984). Numerous methods are available, however, which enable students to clarify their personal value stances: facts relevant to an issue can be examined, possible options and consequences can be explored, current values and principles can be analyzed, respect for basic human needs can be promoted, and values can be modified through questioning and learning (Urbano 1984). The above methods are all utilized in the bioethical component. Although exercises in bioethics have been criticized as pushing preformulated values onto students, studying bioethics does not force values on students, but instead provides them with an opportunity to examine critically currently held values and their consequences and to strengthen, modify, or abandon them in favor of new ones.

Finally, a key feature of bioethics is its focus on decision-making. According to Dr. Jon Hendrix, "the first step in...decision-making is the examination of data and

identification of a problem as being an ethical problem" (Pursifull 1986). Because our future will be increasingly filled with technologies conferring both risks and benefits, decision-making skills are, and will continue to be, a key to our survival.

Method

In attempting to show the relevance of bioethical instruction to today's students, two different bioethical strategies were used with three different test populations. Both bioethical strategies involved the use of a case study on gene therapy, with one strategy using a discussion group in conjunction with the case and the other using a decision-making model. Effectiveness of each strategy was assessed, and the two were compared, with the expectation that both strategies would be equally effective in the populations.

Development of Case Studies

Case studies serve to increase the interest of scientific issues to students by emphasizing the personal relevance of these issues to students' lives. In a case study, scientific information is presented in such a way that students encounter conflict between their values and/or morals with respect to how they should act when faced with an ethical dilemma resulting from scientific knowledge and technology. Since it is inferred that students best internalize information which they find personally meaningful, the case study is anticipated to be a very effective tool in bioethical instruction. Each case study contains issues which have the potential to affect

significantly many areas of society. These issues center around the presentation of the following facts:

I. Scientific/medical facts

II. Historical facts/data

III. Economic facts/data/predictions

IV. Sociological facts/data/predictions

V. Psychological facts/data/predictions

VI. Religious/philosophical data

VII. Legal data/predictions (Mertens and Hendrix 1983).

Through examination of these facts, students identify ethical questions associated with controversial issues.

In choosing a topic for the case study to be developed, it was decided that no current issue in science has a greater potential for creating ethical dilemmas than the ongoing Human Genome Project (HGP). The goal of scientists working on this project is to map the location and determine the function of every gene in the human genome. One outcome of this project is gene therapy, which involves the insertion of a healthy, properly functioning gene into the cells of a person who has a genetic disease or disorder because that particular gene of his own is faulty or nonfunctional. The hope is that the insertion of the new gene will result in the production of enough functional product to compensate for the faulty or nonfunctional gene, thereby making the person healthy. While the original intent of gene therapy is for medical purposes, once the HGP is completed and the locations and functions of all genes

are known, gene therapy for nonmedical purposes could become possible and even likely. This prospect carries an abundance of ethical issues, and it is for this reason that gene therapy was selected as the topic for the case study to be tested.

Although not tested, two other case studies on the HGP were developed. The first concerned the ethical issues that would result if a genetic difference in intelligence among races was discovered, while the second explored the possible consequences to society of the knowledge that certain mental illnesses were genetic. These cases were used as examples in introducing the field of bioethics to one of the test populations and will be tested in conjunction with a discussion group and/or a decision making model at a later date. The cases are included in Appendix A.

Decision-Making Model

Within one of the test populations, the gene therapy case study was used in conjunction with a decision-making model. This model provided students with a format with which to deal with the ethical issues identified in the case study, requiring them to consider all possible solutions, their consequences, and the degree to which they are consistent with their values. The model used in this study was developed by Dr. Jon Hendrix (1978) and was based on the theories of Dr. Jean Piaget, Dr. Lawrence Kohlberg, and Dr. Brian Hall (Pursifull 12). According to Dr. Jon Hendrix,

this methodology assists students in the decision-making process by enabling them to:

1. Recognize and identify a value, moral, or ethical problem;
2. Generate and explore as many alternate solutions to the problem as possible;
3. Clarify personal values pertinent to the problem and the selected solution; and
4. Explore the consequences of implementing their solution (Hendrix 1978).

Together, the case study and decision-making model serve to:

1. Sensitize students to ethical problems created by the application of scientific knowledge;
2. Encourage students to analyze a problem from as many frames of reference as possible by acting on contemporary data;
3. Allow students to synthesize personal decisions after clarifying their own values/morals or ethical principles; and,
4. Permit students to actualize these decisions (when possible) through life's choices (Hendrix 1978; Mertens and Hendrix 1983); (Modified from Dr. Hans Uffelmann 1976).

Discussion Group

In both of the test populations, the case study was used in conjunction with a student discussion group. The

purpose of such a group was to increase each student's awareness of others' views with the hope that their own views would thus be carefully examined, modified, and/or strengthened. According to John K. Brilhart (1978), group dynamics should operate on the following principles:

1. A group should contain a sufficiently small number of people for each member to be aware of and have some reaction to others' views;
2. The success of each member is contingent upon the success of others in achieving the defined goals;
3. Each person in a group should have a sense of belonging or membership, identifying himself with the other members of the group;
4. Oral interaction should be a central element of the discussion; and
5. Behavior in the group is based on norms and procedures agreed upon and accepted by all members.

A concise format of the process followed in group discussions is as follows:

1. Recognize the problem.
2. Describe the problem.
3. Discover solutions.
4. Evaluate proposed solutions; accept the best alternative.
5. Devise a plan of action.

For a complete structural pattern of discussion, see Appendix B.

Test Populations

Two different test populations were used in implementing and evaluating the gene therapy case study as a bioethical strategy. One population consisted of students enrolled in Biology 299, a Ball State University Honors College course. Twenty-two of these students read the case and then participated in a discussion group. The other test population was taken from a Western High School (Russiaville, IN) Advanced Biology class. Thirty-five students participated; 14 of them engaged in a discussion group while 21 completed a decision-making model after reading the case.

Evaluation of the Gene Therapy Case Study

The testing of the value of the gene therapy case study as a bioethical strategy involved three components. First, a pretest was developed and given to all students in the test populations before they received the case study. The pretest consisted of a combination of 18 multiple choice, true/false, and Likert scale questions dealing with both the content of and the ethical issues associated with the HGP (see Appendix A). The pretest was administered as a means of assessing the students' baseline knowledge of gene therapy before receiving the case and participating in a discussion group or completing a decision-making model. Seven performance objectives were devised for the gene therapy case study (see Appendix A), with each objective

corresponding to questions on the pretest. Content validity for these objectives was established by Dr. Jon Hendrix by correctly matching the objectives to their corresponding questions. After the students completed the pretests, they read the case study and either participated in a discussion group or completed a decision-making model. Next, the students were administered a post-test consisting of questions identical to those of the pretest. The post-test was administered to the high school population one week after participation in a discussion group or completion of a decision-making model, while post-tests were administered to the college population one day after participation in a discussion group or completion of a decision-making model. Although a two-week wait was recommended before administration of the post-tests, time constraints would not permit this. Unfortunately, this did not allow us to assess accurately retention rates. Also, the treatment conditions of the two populations differed in that the college population received credit for their participation, while the high school population did not. In an attempt to make these conditions more equal, the high school population was offered extra credit for their participation.

Statistical Methods

In analyzing the data obtained from the pretests and post-tests, three statistical methods were used. For questions 1-8, which deal with content, both a t-test and

ANOVA (analysis of variance) were used as methods of analysis. These tests were executed using the Minitab computer program. The t-test is an appropriate method of analysis when 1) data is interval or ratio, 2) samples are random, 3) populations are normally distributed, and 4) variance is homogeneous (Bartz 1976). When these assumptions are met, the t-test can be used to assess accurately the differences between scores on the pretests and post-tests to determine if they are statistically significant. The hypothesis used to address the question of statistical significance is the null hypothesis. This hypothesis states that there are no differences between the scores on the pretests and the post-tests. Statistical significance is established by rejecting the null hypothesis. Rejection or lack of rejection is determined by comparing a calculated t-value to a critical t-value read from a t-table (Ferguson 1981). Separate t-tests were run for the discussion group populations and the decision-making model populations, and frequency histograms for the pretests and post-tests were compared within each group. Variances for the two populations were also assessed, using ANOVA as the method of analysis. This statistical test is ideal because it allows for comparison of two populations that differ in size (Moore and McCabe 1989). The discussion group population and decision-making model population were analyzed separately by an ANOVA and were then compared graphically. For questions 9-18, means were calculated for

the pretest and post-test responses for each question. The difference between these means was given as a measure of change in attitude and degree of certainty (questions 9-15) and as an assessment of change in decision-making (questions 16-18).

Results and Discussion

In evaluating the effectiveness of the gene therapy case study as a bioethical decision-making strategy, five different methods of analysis were used. These analyses were performed on data obtained from the pretests and the post-tests administered to each test population. They included the t-test for statistical significance, ANOVA (analysis of variance), percent gain, calculations of mean responses, and administration of a survey instrument.

T-test

This statistical method was used to determine if there was a significant increase in scores on the post-tests as compared to scores on the pretests for items 1-8, which deal with content. Using the minitab computer program, raw scores on both tests for each student in a test population were entered, and a t-test was carried out for the population as a whole. The alpha level was set at .05; therefore, statistical significance can be interpreted to mean that the probability of increased scores occurring by chance alone--instead of being due to the bioethical strategy--is less than 5%. Such significance, then, would affirm the value of the strategy as an educational tool. The results for the high-school discussion group and

decision-making model test populations were statistically significant, as were the results for the college test population. Therefore, increases in scores on the pretests as compared to scores on the post-tests were attributed to the bioethical strategy. The raw data and the results of the t-tests for each population are provided in Tables 1-3.

ANOVA

Analysis of variance was used to compare the scores for the high school discussion group and decision-making model test populations on questions 1-8, which deal with content. Using the Minitab computer program, the differences between the pretests and post-tests for the two test populations were entered in separately, and ANOVA was then performed for the two data sets. No significant differences were detected for the two populations; thus, it can be concluded that the discussion group and the decision-making model formats were equally effective in the high school population. The raw data used in ANOVA are provided in Appendices E and F, and the results of ANOVA are given in Tables 4-5. ANOVA was also performed to determine if differences existed between the high school discussion group test population and the college discussion group test population. The results of this test indicated that the bioethical strategy was more effective for the college population than for the high school population. Because the high school population had no bioethical instruction prior to implementation of the

strategy while the college population had received instruction of this type, this finding was expected.

Percent Gain

As an additional method of analysis, percent gain between the number correct on questions 1-8 on the pretest and the number correct on these questions on the post-test was calculated for each student in all of the test populations. This allows for an examination on an individual basis of increased learning resulting from the bioethical strategy. The majority of these values indicated an increased number of correct responses on the post-tests as compared to the number of correct responses on the pretests. The formula for and results of the percent gain calculations are given in Tables 6-7.

Calculations of Mean Responses

In calculating the mean responses for questions 9-18, which deal with decision-making, number values were assigned to the answer choices in such a way that numerical order reflected the continuum of Likert-type answer choices. The numbers corresponding to each part of an individual question were added for an entire test population, and this sum was then divided by the number of total responses. This was done for every question on both the pretests and the post-tests, and the means of the corresponding questions were then compared for both tests. These comparisons provided a

way of assessing the degree of attitudinal change (questions 9-15) and change in decision-making (questions 16-18). The degree, and not the direction, of change was of interest, as any change at all was attributed to the bioethical strategy. These values and their interpretations are provided in Tables 8-10.

Survey Instrument

A final method of evaluation consisted of administering a survey instrument concerning the gene therapy bioethical strategy to students in the test populations. This provided the research participants with an opportunity to give feedback about their own opinions as to the educational effectiveness of the strategy. The survey instrument is found in Appendix A, and the summary of results is given in Tables 11-12.

Table 1

High School Decision-Making Model

ROW	C1	C2	C3
1	4	4	0
2	4	4	0
3	3	5	2
4	1	2	1
5	4	6	2
6	3	4	1
7	3	5	2
8	3	5	2
9	2	5	3
10	2	3	1
11	5	5	0
12	2	3	1
13	5	7	2
14	2	6	4
15	5	6	1
16	4	8	4
17	3	2	-1
18	2	2	0
19	5	1	-4
20	5	1	-4
21	3	5	2

TEST OF MU = 0.000 VS MU N.E. 0.000

	N	MEAN	STDEV	SE MEAN	T	P VALUE
C3	21	4.429	1.777	0.388	11.42	0.0000

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Table 2

High School Discussion Group

ROW	C1	C2	C3
1	2	6	4
2	4	5	1
3	5	4	-1
4	2	3	1
5	5	7	2
6	3	4	1
7	3	6	3
8	3	4	1
9	3	4	1
10	1	3	2
11	1	3	2
12	3	2	-1
13	4	5	1
14	4	1	-3

TEST OF MU = 0.000 VS MU N.E. 0.000

	N	MEAN	STDEV	SE MEAN	T	P VALUE
C3	14	4.071	1.639	0.438	9.29	0.0000

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Table 3

College Discussion Group

ROW	C1	C2	C3
1	2	6	4
2	6	7	1
3	3	7	4
4	5	8	3
5	4	7	3
6	2	6	4
7	2	5	3
8	1	7	6
9	5	6	1
10	1	6	5
11	0	5	5
12	2	4	2
13	2	6	4
14	3	7	4
15	1	6	5
16	1	7	6
17	3	4	1
18	1	5	4
19	3	7	4
20	1	7	6
21	3	3	0
22	5	7	2

Test of MU = 0.000 vs MU N.E. 0.000

	N	MEAN	STDEV	SE MEAN	T	P VALUE
C3	22	3.500	1.739	0.371	9.44	0.00

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Table 4

High School: Discussion Group v. Decision-Making Model

ROW	DIFFDG	DIFFDM
1	4	0
2	1	0
3	-1	2
4	1	1
5	2	2
6	1	1
7	3	2
8	1	2
9	1	3
10	2	1
11	2	0
12	-1	1
13	1	2
14	-3	4
15		1
16		4
17		-1
18		0
19		-4
20		0
21		2

Analysis of Variance

SOURCE	DF	SS	MS	F	p
FACTOR	1	0.08	0.08	0.02	0.876
ERROR	33	101.81	3.09		
TOTAL	34	101.89			

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Table 5

Discussion Group: High School v. College

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	1	53.47	53.47	17.57	0.000
ERROR	34	103.50	3.04		
TOTAL	35	156.97			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	----------+---------+---------+------
C3	22	3.500	1.739	(-----*-----)
C4	14	1.000	1.754	(-------*-------)
				----------+---------+---------+------
POOLED STDEV =		1.745		1.2 2.4 3.6

Table 6

Percent Gain
College Discussion Group

Formula for Percent Gain:

$$\frac{\text{Number correct on post-test - Number correct on pretest}}{\text{Number possible - Number correct on pretest}}$$

ID#	Percent Gain Calculation
1	(6-2)/(8-2) = 4/6 = 66.7%
2	(7-6)/(8-6) = 1/2 = 50%3
3	(7-3)/(8-3) = 4/5 = 80%
4	(8-5)/(8-5) = 3/3 = 100%
5	(7-4)/(8-4) = 3/4 = 75%
6	(6-2)/(8-2) = 4/6 = 66.7%
7	(5-2)/(8-2) = 3/6 = 50%
8	(7-1)/(8-1) = 6/7 = 85.7%
9	(6-5)/(8-5) = 1/3 = 33.3%
10	(6-1)/(8-1) = 5/7 = 71%
11	(5-0)/(8-0) = 5/8 = 62.5%
12	(7-3)/(8-3) = 4/5 = 80%
13	(6-1)/(8-1) = 5/7 = 71.4%
14	(7-1)/(8-7) = 6/7 = 85.7%
15	(4-3)/(8-3) = 1/5 = 20%
16	(5-1)/(8-1) = 4/7 = 57.1%
17	(7-3)/(8-3) = 4/5 = 80%
18	(7-1)/(8-1) = 6/7 = 85.7%
19	(3-3)/(8-5) = 0/3 = 0%
20	(7-5)/(8-5) = 2/3 = 66.7%
21	(4-2)/(8-2) = 2/6 = 33.3%
22	(6-2)/(8-2) = 4/6 = 66.7%

Table 7

Percent Gain
High School Discussion Group
and Decision Making Model

Formula for percent gain:

$$\frac{\text{Number correct on post-test} - \text{Number correct on pretest}}{\text{Number possible} - \text{Number correct on pretest}}$$

ID#	Percent gain calculation (discussion group)	ID#	Percent gain calculation (decision-making model)
1	(6-2)/(8-2) = 4/6 = 66.7%	1	(4-4)/(8-4) = 0/4 = 0%
2	(5-4)/(8-4) = 1/4 = 25%	2	(4-4)/(8-4) = 0/4 = 0%
3	(4-5)/(8-5) = -1/3 = -33.3%	3	(5-3)/(8-3) = 2/5 = 40%
4	(3-2)/(8-2) = 1/6 = 16.7%	4	(2-1)/(8-1) = 1/7 = 14.3%
5	(7-5)/(8-5) = 2/3 = 66.7%	5	(6-4)/(8-4) = 2/4 = 50%
6	(4-3)/(8-3) = 1/5 = 20%	6	(4-3)/(8-3) = 1/5 = 20%
7	(6-3)/(8-3) = 3/5 = 60%	7	(5-3)/(8-3) = 2/5 = 40%
8	(4-3)/(8-3) = 1/5 = 20%	8	(5-3)/(8-3) = 2/5 = 40%
9	(4-3)/(8-3) = 1/5 = 20%	9	(5-2)/(8-2) = 3/6 = 50%
10	(3-1)/(8-1) = 2/7 = 28.6%	10	(3-2)/(8-2) = 1/6 = 16.7%
11	(3-1)/(8-1) = 2/7 = 28.6%	11	(5-5)/(8-5) = 0/5 = 0%
12	(2-3)/(8-3) = -1/5 = -20%	12	(3-2)/(8-2) = 1/6 = 16.7%
13	(5-4)/(8-4) = 1/4 = 25%	13	(7-5)/(8-5) = 2/3 = 66.7%
14	(1-4)/(8-4) = -3/4 = -75%	14	(6-2)/(8-2) = 4/6 = 66.7%
		15	(6-5)/(8-5) = 1/3 = 33.3%
		16	(8-4)/(8-4) = 4/4 = 100%
		17	(2-3)/(8-3) = -1/5 = -20%
		18	(2-2)/(8-2) = 0/6 = 0%
		19	(1-5)/(8-5) = -4/3 = -133%
		20	(5-5)/(8-5) = 0/3 = 0%
		21	(5-3)/(8-3) = 2/5 = 40%

Table 8

Data Analysis
Mean Tables for College Discussion Group (N=22)
Questions 9-18

The following questions vary in the number of answer choices and also in the way that each multiple choice letter (A,B,C,and D) was coded. The difference in coding was necessary because a continuum was developed for the answers in which alphabetically consecutive answer choices on the pretests and the post-tests (such as the choice of 'A' on the pretest and 'B' on the post-test) represented a lesser degree of change than did alphabetically nonconsecutive answers on the pretests and the post-tests (such as 'A' on the pretest and 'C' on the post-test). Because of these differences, codings of responses for each individual question are given to facilitate interpretation. The test, which can be found in Appendix A, should be referred to when viewing the results.

9. PART ONE OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.54	2.04	.50

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that gene therapy is ethically defensible for only medical purposes and the attitude that gene therapy is ethically defensible for both medical and nonmedical purposes. However, this attitude leaned slightly toward the latter viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the belief that gene therapy is ethically defensible for only medical purposes.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.64	3.18	.54

Interpretation of mean values of responses:

Students' mean certainty level regarding their attitudes on the above issue, as indicated on the pretests, fell betweeen that of somewhat uncertain and somewhat certain. However, this mean certainty leaned somewhat toward the latter level. The mean certainty level, as indicated on the post-tests, moved to between the level of somewhat certain and very certain.

10. PART ONE OF QUESTION:

Coding of answer choices: A=3, B=2, C=1

Mean values of responses:

Pretest	Post-test	Difference
1.23	1.41	.18

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that it is sometimes ethical for an employer to coerce an employee to undergo gene therapy and the attitude that it is never ethical for for an employer to coerce an employee to undergo gene therapy. However, this attitude leaned slightly toward the latter viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the belief that it is sometimes ethical for an employer to coerce and employee to undergo gene therapy.

PART TWO OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
3.36	3.23	.13

Interpretation of mean values of responses:

Students' mean certainty level regarding their attitudes on the above issue, as indicated on the pretests, fell between that of somewhat certain and very certain. However, this mean certainty leaned somewhat toward the former level. The mean certainty level, as indicated on the post-tests, moved even more toward that of somewhat certain.

11. PART ONE OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.77	2.50	.27

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that only somatic-cell gene therapy and both germ-cell and somatic-cell gene therapy is/are usually ethical. However, this attitude leaned very strongly toward the latter viewpoint. Students' mean attitude, as indicated on the post-tests, moved more toward the viewpoint htat only somatic-cell gene therapy is usually ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.41	2.86	.45

Interpretation of mean values of responses:

Students' mean certainty level, regarding their attitudes on the above issue, fell between that of somewhat uncertain and somewhat certain. However, this mean certainty leaned leaned slightly toward the former level. The mean certainty level, as indicated on the post-tests, moved more toward that of somewhat certain.

12. PART ONE OF QUESTION:

Coding of answer choices: A=3, B=4, C=1, D=2

Mean values of responses:

Pretest	Post-test	Difference
2.91	2.50	.41

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that only germ-cell gene therapy

is never ethical and the attitude that neither germ-cell nor somatic-cell gene therapy is never ethical. However, this attitude leaned especially strongly toward the latter viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the belief that only germ-cell gene therapy is never ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.64	2.68	.04

Interpretation of mean values of responses:

Students' mean certainty level, regarding their attitudes on the above issue, as indicated on the pretests, fell between that of somewhat uncertain of and somewhat certain of. However, this mean certainty leaned slighly toward the latter level. The mean certainty level, as indicated on the post-tests, moved more toward that of somewhat certain.

13. PART ONE OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.82	2.95	.13

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that only somatic-cell gene therapy is sometimes ethical and the attitude that both germ-cell and somatic-cell gene therapy are sometimes ethical. However, this mean attitude leaned strongly toward the latter viewpoint. The mean attitude, as indicated on the post-tests, moved even more toward the viewpoint that both germ-cell and somatic-cell gene therapy are sometimes ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.68	2.82	.14

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated on the pretests, fell between that of somewhat uncertain and somewhat certain. However, this mean certainty leaned slightly toward the latter level. Students' mean certainty, as indicated on the post-tests, moved even more toward that of somewhat certain.

14. Because of the way this question was constructed, it did not make sense to quantify the response values.

15. PART ONE OF QUESTION:

Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.23	1.27	.04

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that the technological applications of the HGP should not be available to everyone and the belief that the technological applications of the HGP should be available to everyone. However, this mean attitude leaned strongly toward the former viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the belief that the technological applications of the HGP should be available to everyone.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.32	2.77	.45

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated by the pretests, fell between that of somewhat uncertain of and somewhat certain of. However, this mean certainty leaned somewhat strongly toward the former level. The mean certainty level, as indicated by the post-tests, moved much more toward that of somewhat certain.

16. Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.04	1.00	.04

Interpretation of mean values of responses:

Students' mean attitude score, as indicated by the pretests, fell between the attitude that they would be reluctant to undergo gene therapy for the purpose of increasing their intelligence and the attitude that they would be eager to undergo gene therapy for the purpose of increasing their intelligence. However, this mean attitude leaned especially strongly toward the former viewpoint. The mean attitude, as indicated by the post-tests, moved even more toward this belief.

17. Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.00	.91	.09

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, was that of noncompliance with an employer's coercion to undergo gene therapy. The mean attitude.as indicated on the post-tests remained close to this viewpoint.

18. Coding of answer choices: A=1, B=2

Mean values of responses:

Pretest	Post-test	Difference
1.27	.91	.36

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, was between that of reluctance to undergo gene therapy which would increase their future childrens' intelligence and eagerness to undergo gene therapy which would increase their future childrens' intelligence. The mean attitude, as indicated on the post-tests, moved closer to the former viewpoint.

Table 9

Data Analysis
Mean Tables for High School Discussion Group (N=14)
Questions 9-18

The following questions vary in the number of answer choices and also in the way that each multiple choice letter (A,B,C,and D) was coded. The difference in coding was necessary because a continuum was developed for the answers in which alphabetically consecutive answer choices on the pretests and the posttests (such as the choice of 'A' on the pretest and 'B' on the post-test) represented a lesser degree of change than did alphabetically nonconsecutive answers on the pretests and the post-tests (such as 'A' on the pretest and 'C' on the post-test). Because of these differences, codings of responses for each individual question are given to facilitate interpretation. The test, which can be found in Appendix , should be referred to when viewing the following results.

9. PART ONE OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.07	2.36	.29

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that gene therapy is ethically defensible for only medical purposes and the attitude that gene therapy is ethically defensible for both medical and non-medical purposes. However, this attitude leaned very strongly toward the former viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the belief that gene therapy is ethically defensible for both medical and non-medical purposes.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.36	3.21	.85

Interpretation of mean values of responses:

Students' mean certainty level regarding their attitudes on the above issue, as indicated on the pre-tests, fell between that of somewhat uncertain and somewhat certain. However, this mean certainty leaned strongly toward the former level. The mean certainty level, as indicated on the post-tests, moved to between the level of somewhat certain and very certain.

10. PART ONE OF QUESTION:

Coding of answer choices: A=3, B=2, C=1

Mean values of responses:

Pretest	Post-test	Difference
1.5	1.07	.43

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell exactly between the attitude that it is sometimes ethical for an employer to coerce an employee to undergo gene therapy and the attitude that it is never ethical for an employer to coerce an employee to undergo gene therapy. The mean attitude, as indicated on the post-tests, moved more toward the belief that it is never ethical for an employer to coerce an employee to undergo gene therapy.

PART TWO OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
3.0	3.5	.50

Interpretation of mean values of responses:

Students' mean certainty level regarding their attitudes on the above issue, as indicated on the pretests, was that of somewhat certain. The average certainty level, as indicated on the post-tests, moved more toward that of very certain.

11. PART ONE OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.14	2.36	.22

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that only somatic-cell gene therapy and both germ-cell and somatic-cell gene therapy is usually ethical. However, this attitude leaned very strongly toward the former viewpoint. Students' mean attitude, as indicated on the post-tests, moved toward the viewpoint that both germ-cell and somatic-cell gene therapy are usually ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
1.5	2.64	.22

Interpretation of mean values of responses:

Students'mean certainty level, regarding their attitudes on the above issue, was exactly between that of very uncertain and somewhat uncertain. The mean certainty level, as indicated on the post-tests, moved to between that of somewhat uncertain and somewhat certain.

12. PART ONE OF QUESTION:

Coding of answer choices: A=3, B=4, C=1, D=2

Mean values of responses:

Pretest	Post-test	Difference
2.07	2.29	.22

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that only germ-cell gene therapy is never ethical and the attitude that neither germ-cell nor somatic-cell gene therapy is never ethical. However, this attitude leaned especially strongly toward the former

viewpoint. The mean attitude, as indicated on the post-tests, moved toward the belief that neither germ-cell nor somatic cell gene therapy is never ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
1.93	2.21	.28

Interpretation of mean values of responses:

Students' mean certainty level, regarding their attitudes on the above issue, as indicated by the pretests, fell between that of very uncertain of and somewhat uncertain of. However, this mean certainty leaned especially strongly toward the latter level. The mean certainty level, as indicated on the post-tests, moved to that of somewhat uncertain and somewhat certain.

13. PART ONE OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.57	2.36	.21

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that only somatic-cell gene therapy is sometimes ethical and the attitude that both germ-cell and somatic-cell gene therapy are sometimes ethical. However, this mean attitude leaned slightly toward the viewpoint that both germ-cell and somatic-cell gene therapy are sometimes ethical. The mean attitude, as indicated on the post-tests, moved more toward the viewpoint that only somatic-cell gene therapy is sometimes ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference

1.79	2.5	.71

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated on the pretests, fell between very uncertain and somewhat uncertain. However, this level leaned strongly toward that of somewhat uncertain. The mean certainty level, as indicated on the post-tests, moved to that between somewhat uncertain and somewhat certain.

14. Because of the way this question was constructed, it did not make sense to quantify the response values.

15. PART ONE OF QUESTION:

Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.43	1.57	.14

Interpretation of mean values of responses:

Students' mean attitude score, as indicated by the pretests, fell between the belief that the technological applications of the HGP should not be available to everyone and the belief that the technological applications of the HGP should be available to everyone. However, this mean attitude leaned slightly toward the former viewpoint. The mean attitude, as indicated by the post-tests, moved more toward the belief that the technological applications of the HGP should be available to everyone.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.29	2.93	.64

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated by the pretests, fell between that of somewhat uncertain and somewhat certain of. However, this mean

certainty leaned strongly toward the former level. The mean certainty level, as indicated by the post-tests, moved more toward that of somewhat certain.

16. Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.29	1.14	.15

Interpretation of mean values of responses:

Students' mean attitude score, as indicated by the pretests, fell between the attitude that they would be reluctant to undergo gene therapy for the purpose of increasing their intelligence and the attitude that they would be eager to undergo gene therapy for the purpose of increasing their intelligence. However, this mean attitude leaned strongly toward the former viewpoint. The mean attitude, as indicated by the pretests, moved more toward this belief.

17. Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.14	1.14	0

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between that of noncompliance with an employer's coercion to undergo gene therapy and that of compliance with an employer's coercion to undergo gene therapy. However, this mean attitude leaned very strongly toward the former viewpoint. The mean attitude, as indicated on the post-tests, was exactly the same as that on the pretests.

18. Coding of answer responses: A=1, B=2

Mean values of responses:

Pretest	Post-test	Difference
1.5	1.21	.29

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, was that exactly between eagerness and lack of eagerness to undergo gene therapy which would result in not only their own intelligence being increased, but also their children's. The mean attitude, as indicated on the post-tests, moved more toward lack of eagerness to undergo gene therapy which would result in not only their own intelligence being increased, but also their children's.

Table 10

Data Analysis
Mean Tables for High School Decision-Making Model (N=21)
Questions 9-15

The following questions vary in the number of answer choices and also in the way that each multiple choice letter (A,B,C, and D) was coded. The difference in coding was necessary because a continuum was developed for the answers in which alphabetically consecutive answer choices on the pretests and the post-tests (such as the choice of 'A' on the pretest and 'B' on the post-test) represented a lesser degree of change than did alphabetically nonconsecutive answers on the pretests and the post-tests (such as 'A' on the pretest and 'C' on the post-test). Because of these differences, codings of responses for each individual question are given to facilitate interpretation. The test, which can be found in Appendix A, should be referred to when viewing the following results.

9. PART ONE OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.24	2.48	.24

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that gene therapy is ethically defensible for only medical purposes and the attitude that gene therapy is ethically defensible for both medical and non-medical purposes. However, this mean attitude leaned strongly toward the former viewpoint. The mean attutude, as indicated on the post-tests, moved more toward the belief that gene therapy is ethically defensible for both medical and nonmedical purposes.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
2.05	3.0	.95

Interpretation of mean values of responses:

Students' mean certainty level, regarding their attitudes on the above issue, fell between that of somewhat uncertain and that of somewhat certain. However, this mean certainty leaned especially strongly toward the former level. The mean certainty level, as indicated on the post-tests, moved to exactly somewhat certain.

10. PART ONE OF QUESTION:

Coding of answer choices: A=3, B=2, C=1

Mean values of responses:

Pretest	Post-test	Difference
1.30	1.10	.20

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the attitude that it is never ethical for an employer to coerce an employee to undergo gene therapy and the attitude that it is sometimes ethical for an employer to coerce an employee to undergo gene therapy. However, this mean attitude leaned strongly toward the former viewpoint. the mean attitude, as indicated on the post-tests, moved even more toward this viewpoint.

PART TWO OF QUESTION

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.71	3.38	.67

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated on the pretests, fell between that of somewhat uncertain and somewhat certain. However, this mean certainty leaned strongly toward the latter level. The mean certainty, as indicated on the post-tests, moved to somewhat certain.

11. PART ONE OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.81	2.67	.14

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the viewpoints that only somatic-cell and both germ-cell and somatic-cell gene therapy are usually ethical. However, this mean attitude leaned very strongly toward the latter viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the viewpoint that only somatic-cell gene therapy is usually ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
1.90	2.67	.77

Interpretation of mean values of responses:

Students' mean certainty level regarding their attitude on the above issue, as indicated on the pretests, fell between that of very uncertain and somewhat uncertain. However, this mean certainty leaned very strongly toward the latter level. The mean certainty level, as indicated on the post-tests, moved to that of somewhat uncertain.

12. PART ONE OF QUESTION:

Coding of answer choices: A=3, B=4, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
3.10	2.52.	.58

Interpretation of mean values of responses:

Students'mean attitude, as indicated on the pretests, fell between the attitude that neither germ-cell nor somatic-cell gene therapy is never ethical and the attitude that only

somatic-cell gene therapy is never ethical. However, the mean attitude leaned strongly toward the former viewpoint. The mean attitude, as indicated on the post-tests, moved to between the beliefs that both somatic-cell and germ-cell gene therapy and neither germ-cell nor somatic-cell gene therapy is never ethical.

PART TWO OF QUESTION:

Coding for answer choices: A=4, B=3, C=2, D=1

Mean values for responses:

Pretest	Post-test	Difference
2.05	2.95	.90

Interpretation of mean values for responses:

Students' mean certainty level regarding their attitudes on the above issue, as indicated by the pretests, fell between that of somewhat uncertain and somewhat certain. However, the mean certainty leaned especially strongly toward the former level. The mean certainty level, as indicated on the post-tests, moved much more toward that of somewhat certain.

13. PART ONE OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
2.95	2.71	.24

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between the viewpoints that only somatic-cell and that both germ-cell and somatic-cell gene therapy is/are sometimes ethical. However, this mean attitude leaned especially strongly toward the latter viewpoint. The mean attitude, as indicated on the post-tests, moved more toward the belief that only somatic-cell gene therapy is sometimes ethical.

PART TWO OF QUESTION:

Coding of answer choices: A=4, B=3, C=2, D=1

Mean values of responses:

Pretest	Post-test	Difference
1.86	2.62	.76

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated on the pretests, fell between that of very certain and somewhat certain. However, this mean certainty leaned strongly toward the latter level. The mean certainty level, as indicated on the post-tests, moved to between somewhat uncertain of and somewhat certain of.

14. Because of the way this question was constructed, it did not make sense to quantify the response values.

15. PART ONE OF QUESTION:

Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.52	1.43	.09

Interpretation of mean values of responses:

Students' mean attitude, as indicated by the pretests, fell between the viewpoint that the technological applications of the HGP should not be available to everyone and the viewpoint that the technological applications of the HGP should be available to everyone. However, this mean attitude leaned very slightly toward the latter attitude. The mean attitude, as indicated on the post-tests, moved more toward the viewpoint that the technological applications of the HGP should not be available to everyone.

PART TWO OF QUESTION:

Coding of answer choices: A=1, B=2, C=3, D=4

Mean values of responses:

Pretest	Post-test	Difference
1.52	1.43	.09

Interpretation of mean values of responses:

Students' mean certainty level regarding the above issue, as indicated by the pretests, fell between that of somewhat

uncertain of and somewhat certain of. However, this mean certainty leaned very slightly toward the former viewpoint. The mean certainty level, as indicated by the post-tests, moved to that of somewhat certain.

16. Coding of answer choices: A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.38	1.24	.14

Interpretation of mean values of responses:

Students' mean attitude, as indicated by the pretests, fell between the attitude that they would be reluctant to undergo gene therapy for the purpose of increasing their intelligence and the attitude that they would be eager to undergo gene therapy for the purpose of increasing their intelligence. However, this mean certainty leaned somewhat toward the former viewpoint. The mean attitude, as indicated by the post-tests, moved even more toward this viewpoint.

17. Coding of answer choices; A=2, B=1

Mean values of responses:

Pretest	Post-test	Difference
1.05	1.00	.05

Interpretation of mean values of responses:

Students' mean attitude, as indicated on the pretests, fell between that of noncompliance and that of compliance with an employer's coercion to undergo gene therapy. However, this mean attitude leaned especially strongly toward the former viewpoint. The mean attitude, as indicated by the post-tests, moved to exactly this viewpoint.

18. Coding of answer choices: A=1, B=2

Mean values of responses:

Pretest	Post-test	Difference
1.38	1.19	.19

Interpretation of mean values of responses:

Students' mean attitude score, as indicated on the pretests, fell between that of a lack of eagerness and that of eagerness to undergo gene therapy which would result in not only their own intelligence being increased, but also their children's. However, this mean attitude leaned somewhat toward the former viewpoint. The mean attitude, as indicated by the post-tests, moved even more toward this viewpoint.

Table 11

Survey Instrument
College Discussion Group
(N=22)

1. I feel that the bioethical strategy on gene therapy has increased my knowledge of what is involved in gene therapy.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	0%	0%	72.7%	27.3%

2. I feel that the bioethical strategy on gene therapy has increased my awareness of the ethical issues associated with gene therapy.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	0%	0%	54.5%	45.4%

3. I feel that the bioethical strategy on gene therapy has helped me clarify my own personal feelings and values related to this issue.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	0%	13.6%	72.7%	13.6%

4. I feel that the bioethical strategy on gene therapy was a valuable component of this course.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	0%	9.1%	68.2%	22.7%

5. I feel that the time spent on the bioethical strategy was worthwhile.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	0%	0%	68.2%	31.8%

Table 12

Survey Instrument
High School Discussion Group
and Decision Making Model
(N=35)

1. I feel that the bioethical strategy on gene therapy has increased my knowledge of what is involved in gene therapy.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	2.8%	14.3%	71.4%	11.4%

2. I feel that the bioethical strategy on gene therapy has increased my awareness of the ethical issues associated with gene therapy.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	2.8%	22.8%	57.1%	17.1%

3. I feel that the bioethical strategy on gene therapy has helped me clarify my own personal feelings and values related to this issue.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	2.8%	31.4%	42.8%	22.8%

4. I feel that the bioethical strategy on gene therapy was a valuable component of this course.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	22.8%	31.4%	34.2%	11.4%

5. I feel that the time spent on the bioethical strategy was worthwhile.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
0%	8.6%	31.4%	40%	20%

Conclusions and Recommendations

The gene therapy case study was developed as a teaching strategy to be used in conjunction with either a decision-making model or discussion group in Biology 299, an Honors College course at Ball State University. This case study presented students with factual information about gene therapy and also provided them with the opportunity to clarify their values and improve their decision-making skills in dealing with ethical issues resulting from this technology. The case study was implemented in the Biology 299 course and also in an Advanced Biology class at Western High School in Russiaville, IN. The intent was to demonstrate that the bioethical strategy is appropriate for high school students as well as for college students. In evaluating the gene therapy case study for its effectiveness as a bioethical strategy, a testing instrument was developed. This instrument contained questions dealing with content, attitude, and decision-making skills and was administered to students in the test populations both before and after they received the case study and completed a decision-making model or participated in a discussion group. Differences in scores on the pretests and post-tests were then assessed and were used as a measure of learning that

resulted from the bioethical strategy. The data obtained from the tests indicated that statistically significant differences in learning occurred as a result of the gene therapy strategy. This effect was observed in both the high school and college test populations. Thus, it was concluded that the strategy is effective for both college and high school students. In comparing the performance of students in the decision-making model population with those in the discussion group population, however, statistically significant differences were not observed. Therefore, it was concluded that both bioethical strategies are equally effective.

After conducting this research over the course of a year, I have several recommendations that I would suggest for future research of similar nature. First, the testing instrument should be developed in such a way that would facilitate ease of evaluation. Although the testing instrument used for this research displayed good content validity, its format greatly complicated analysis of data. Second, enough time should be allotted for the recommended period between use of the bioethical strategy and administration of the post-test. Because time constraints required us to shorten the amount of time between the two, retention rates could not be assessed accurately. Finally, because our research design was not parallel in the sense that the entire college population participated in a discussion group while only half of the high school

population participated in a discussion group while the other half completed a decision-making model, comparisons between two populations receiving the same treatment group was not possible. More conclusions could likely be drawn from a design which is more parallel in nature.

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Appendix A

Gene Therapy Objectives

1. Students will be able to identify the goals of and rationale behind the Human Genome Project (HGP). (questions 1,14)

2. Students will be able to identify the goals of and rationale behind gene therapy. (questions 2,3)

3. Students will be able to identify the procedures used in gene therapy. (questions 5,16).

4. Students will be able to distinguish between somatic-cell and germ-cell gene therapy. (questions 4,15)

5. Students will be able to state whether or not they believe various types of gene therapy are ethical and if so, in what circumstances. (questions 6,7,8)

6. Students will be able to state their opinions concerning the beneficence/maleficence of the HGP. (questions 9,18)

7. Students will determine and defend how they would act if offered or coerced to undergo gene therapy. (questions 11,12,13)

Gene Therapy Case Study
Pre/Post-test

I. Multiple Choice

1. Upon completion, the Human Genome Project (HGP) will result in:
   A) knowledge of the location of all human genes on their specific chromosomes.
   B) extensive chemical analyses of all genes known to exist in the human genome.
   C) determination of all human diseases known to have a genetic basis.
   D) knowledge of the chromosomal function of every gene.

2. Gene therapy involves:
   A) chemically modifying disease-causing or faulty genes so that they are healthy and function normally.
   B) the insertion of healthy genes into a human being with the intent of replacing faulty or disease-causing genes.
   C) the administration of drugs to patients with genetic afflictions in an attempt to counteract the effects of disease-causing genes.
   D) introducing an artificially synthesized enzyme into the cells of a patient whose own genes produce the enzyme in a deficient amount.

3. In human gene therapy, the most common method by which DNA is introduced is:
   A) microinjection.
   B) gene surgery.
   C) viral carriers.
   D) transfection.

4. In mapping the gene sequences of human genomes, the following will be used:
   A) genetic maps
   B) recombinant DNA
   C) physical maps
   D) all of the above

II. True/False: Correct any false statements so that they become true.

5. T F Gene therapy is of greatest benefit to those who are known to be genetically predisposed to develop a certain disease; for those who are already afflicted, the procedure is of no value.

6. T F Somatic-cell gene therapy differs from germ-cell gene therapy in that resulting genetic alterations can be passed on to future generations.

7. T F Germ-cell gene therapy does not involve the insertion of healthy, functioning genes into cells whose genetic material is being degraded by infectious agents.

8. T F Microinjection involves using microorganisms to incorporate genetic material into the cells of gene therapy patients.

III. Multiple Choice--Likert Scale

9. I believe that gene therapy is ethically defensible for: a) neither medical nor nonmedical b) only medical c) both medical and nonmedical d) only nonmedical purposes.
I am: a) very uncertain of b) somewhat uncertain of c) somewhat certain of d) very certain of this stance.

10. I believe that it is: a) always b) sometimes c) never ethical for an employer to coerce an employee to undergo gene therapy.
I am: a) very certain of b) somewhat certain of c) somewhat uncertain of d) very uncertain of this stance.

11. I believe that: a) only germ-cell b) both germ-cell and somatic-cell c) only somatic-cell d) neither germ-cell nor somatic-cell gene therapy is/are usually ethical.
I am: a) very uncertain of b) somewhat uncertain of c) somewhat certain of d) very certain of this stance.

12. I believe that: a) neither germ-cell nor somatic-cell b) only somatic-cell c) both somatic-cell and germ-cell d) only germ-cell gene therapy is/are never ethical.
I am: a) very certain of b) somewhat certain of c) somewhat uncertain of d) very uncertain of this stance.

13. I believe that: a) only germ-cell b) both germ-cell and somatic-cell c) only somatic-cell d) neither somatic-cell nor germ-cell gene therapy is/are sometimes ethical.
I am: a) very uncertain of b) somewhat uncertain of c) somewhat certain of d) very certain of this stance.

14. I believe that the: a) benefits b) risks to society resulting from the completion of the HGP will: a) outweigh b) be equal to the: a) risks b) benefits it will confer.
I am: a) very certain of b) somewhat certain of c) somewhat uncertain of d) very uncertain of this stance.

15. I believe that the technological applications of the HGP: a) should be b) should not be available to everyone.
I am: a) very uncertain of b) somewhat uncertain of c) somewhat certain of d) very certain of this stance.

IV. Application of decision-making skills: Please answer in 3-5 sentences.

16. If gene therapy that would increase my intelligence were available to me, I would be: a) eager b) reluctant to receive it. Explain/support your position.

17. If my employer threatened to reduce my salary or fire me for refusing to undergo gene therapy, I: a) would b) would not comply with his wishes.

18. If the gene therapy discussed in #16 would also affect any future children I might have, I: a) would not be b) would be eager to undergo it for this reason alone. Explain/support your position.

Survey Instrument

1. I feel that the bioethical strategy on gene therapy has increased my knowledge of what is involved in gene therapy.

   Strongly Disagree.....Disagree.....Undecided.....Agree.....Strongly Agree

2. I feel that the bioethical strategy on gene therapy has increased my awareness of the ethical issues associated with gene therapy.

   Strongly Disagree.....Disagree.....Undecided.....Agree.....Strongly Agree

3. I feel that the bioethical strategy on gene therapy has helped me clarify my own personal feelings and values related to this issue.

   Strongly Disagree.....Disagree.....Undecided.....Agree.....Strongly Agree

4. I feel that the bioethical strategy on gene therapy was a valuable component of this course.

   Strongly Disagree.....Disagree.....Undecided.....Agree.....Strongly Agree

5. I feel that the time spent on the bioethical strategy was worthwhile.

   Strongly Disagree.....Disagree.....Undecided.....Agree.....Strongly Agree

Appendix B